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ABSTRACT

World knowledge is defined as information that is acquired by adults from life experiences. To investigate question answering processes involving world knowledge systems, 120 young, middle-aged and older adults were given questions intended to induce either fact retrieval or inferential reasoning. Multiple-choice and true/false formats were used. The number of correct responses, response time, and subjects' confidence in their responses were recorded. Results showed that the questions elicited appropriate differential cognitive processes for all ages and that both types of cognitive processes were slowed by aging. Older adults, however, were as confident or more confident in their responses than younger adults. The evidence indicates that older adults can accurately and effectively use both fact retrieval and inferential reasoning from world knowledge systems as long as their working memory capacity is not strained. (Author/LLL)

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Utilizationof Fact Retrieval and Inferential Reasoning in Young, Middle-Aged, and Elderly Adults[1]

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Abstract

This study investigates question answering processes involving 'world knowledge' systems utilized by young, middle aged, and older adults. Questions intended to induce either fact retrieval or inferential reasoning were utilized in both a multiple choice and true/false format. Dependent measures included the number of correct responses, speed of response, and confidence in the response. Results show that the questions elicited appropriate differential cognitive processes for all ages and that both types of cognitive processes are slowed by aging. Older adults, however, were as confident or more confident in their responses than younger adults. Evidence indicates that older adults can accurately and effectively use both fact retrieval and inferential reasoning from world knowledge systems as long as their working memory capacity is not strained.

Key words: Memory, Question-answering, Fact retrieval, Inference

This research represents the latest in a series of studies designed to investigate how adults utilize "world knowledge" systems. World knowledge is defined as information that is acquired from life experiences by adults. Camp, Lachman, and Lachman (1980) developed a methodology using world knowledge questions that were designed to elicit two different reasoning processes. The first type of question was intended to induce a fact retrieval process. For example, "Who was 'Old Hickory'?"-- answer: Jackson. In this case, one simply needs to remember a fact. The second type of question was designed to induce an inferential reasoning process. For example, "Which western hero would the wolfman fear most?"-- answer: The Lone Ranger (since he shoots silver bullets). In this instance, one needs to piece together facts and create a new association by inferring or 'figuring out' the answer. Although these two processes are distinct (Camp, 1981; Camp et al., 1980), the relationship between age level and performance based on these processes remains unclear. There does seem to be some tendency for the performance of older adults to improve in comparison to that of younger adults as experimental stimuli and tasks increase in ecological validity.

Though age-related declines have been found for remembering lists of words (Craik, 1977; Erber, 1974; Harwood & Naylor, 1969), the evidence does not support the decline when remembering common facts (i.e. world knowledge) (Botwinick and Storandt, 1974; 1980; Lachman and Lachman, 1980; Perlmutter, 1978).

With respect to inferential reasoning, Cohen (1981) found

that older adults were unable to make inferences as well as younger adults; however, Belmore (1981) and Light, Zelinski, and Moore (1982) found that older adults could effectively make inferences from sentences, but showed deficits in the recall of these sentences. Light et al. attribute their findings to the fact that Cohen's stimuli were more abstract than sentences typically encountered by older adults. Recall deficits in older adults were attributed to a decrease in working memory capacity in older adults.

When older and younger adults were matched for gender and occupation (e.g. female schoolteachers, Lachman, Lachman & Taylor (1982)), older adults outperformed younger adults in tasks involving both fact retrieval and inferential reasoning. Lachman et al. used a multiple choice task for these stimuli and this homogeneous sample. Stimuli used involved world knowledge questions.

Camp (1981) used similar stimulus questions in both a multiple choice and a true/false task with a more heterogeneous sample of younger and older adults. In the true/false task older adults did as well as the younger adults in answering questions requiring both fact retrieval and inferential reasoning. However, for a multiple choice task using these questions, younger adults correctly answered more questions than older adults. If the multiple choice task could be construed as placing more demands on working memory capacity than a true/false task (since four alternatives are presented rather than one), this outcome could be interpreted as supporting the conclusions of Light et al. Kausler & Kleim (1978) have also found that the

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magnitude of age deficits (e.g. error scores) in multiple-item recognition memory increases as the number of incorrect alternatives increase.

Another set of findings from this line of research (Camp, 1981; Camp et al., 1980) was that questions intended to elicit fact retrieval (i.e. fact retrieval initiators) were answered much more rapidly than questions intended to elicit inferential reasoning (i.e. inference initiators). Older adults also took longer to respond to both types of questions than younger adults. In addition, older adults reported using more inferential reasoning than younger adults. There are three possible explanations for these results:

1) Older adults engage in more inferential reasoning than younger adults since it is more difficult for them to retrieve facts and thus use inferential reasoning by default.

2) Older adults have a greater willingness to engage in inferential reasoning since they are less confident in their ability to remember facts, perhaps due to stereotypes about loss of ability to "remember" with advancing age.

3) There is a general systemic slowdown associated with increasing age for all types of information processing. This produces slowing of both fact retrieval and inferential reasoning in older adults, independent of self-reported process utilization.

This study was conducted to further evaluate these hypotheses by using world knowledge questions similar to those used in previous research in both multiple choice and true/false tasks. Middle aged adults were included in addition to younger and older

adults.

METHODS

Subjects. Participants were all Caucasian and selected from each of three age groups-- young, middle aged, and older adults-- with 27 females and 13 males per group (N=120). Average age of the groups were 27, 46, and 70 years, respectively. These volunteers were from Hays, Kansas and its immediate vicinity. They were paid $20 dollars for their participation. All were given demographic questionnaires. Results indicated that the subjects could be considered "well-educated" and in good health. All had normal or corrected vision. In addition, they were administered the WAIS-R Information and Similarities subtests. The Information subtest yielded significant results ($F=5.07$, $df=2,117$, $p<.01$, $w^2=.06$) with mean raw scores increasing as age increased age (M=19.8, 21.6, and 22.9 for young, middle, and older aged groups, respectively). Post hoc comparisons revealed that mean performance for the older adults was significantly better than mean performance for the younger adults ($p < .01$). Middle aged adults' mean performance was not significantly different from that of the younger or older adults. The Similarities subtest mean raw scores were not significantly different across age groups (M=20.0, 20.8, and 20.6 for young, middle, and older aged groups, respectively). All participants also demonstrated the ability to read aloud a series of practice words and short sentences displayed on the monitor of the same microcomputer used to present experimental stimuli.

Stimuli. Multiple choice and true/false tasks were created

using 120 world knowledge questions. Of these questions, 60 were fact retrieval initiators and 60 were inference initiators. In the multiple choice task, four alternative answers were listed. One answer was correct, one sounded like the correct answer, one was semantically related to the correct answer, and one sounded like the semantically related false alternative. For example, the four choices to the question "What is the capital of Lebanon?" were Beirut, Birren, Damascus, and Demetas. The stimuli were presented on a Radio Shack Model III Microcomputer. A machine language subroutine activated by presentation of questions or answers and terminated by pressing the keyboard's spacebar was used to measure reaction time.

Procedure. In both the multiple choice and true/false tasks, each participant was presented with 30 fact retrieval and 30 inference initiators. Prior to beginning the experiment, all participants had familiarized themselves with the procedure with sample practice questions. Only one question appeared at a time, and a different random order of presentation was used for each subject. In the multiple choice task, a question appeared on the screen. The participant pressed the spacebar after the question had been read. The speed with which the sentence was read was then recorded. Four alternatives were then displayed on the microcomputer screen. The respondent selected an answer and pressed the spacebar. The speed of answer selection was then recorded. The respondent next verbalized the selection. The experimenter then recorded the verbal response by pressing the appropriately coded button - "a", "b", "c", or "d", or "true", "false" on a separate input panel. These inputs were then

transferred to the memory of the microcomputer. Following the selection of an answer, the participant indicated on a three-point scale the type of reasoning process used in answering the question (i.e. rated on 1-- mostly remembered; 2-- mostly eliminated alternatives; 3-- mostly figured out the response). Next, a second scale had the subjects rate their confidence in their response (ie. rated on 1-- certainly right; 2-- probably right; 3-- probably wrong; 4-- random choice).

In the true/false task, identical measures were taken except that only one choice appeared after each question. Participants then decided whether the choice was correct or not ("true" or "false"). Time to make this decision was recorded, along with level of confidence in the decision. Since only one alternative was presented, no rating for reasoning process was used.

RESULTS

Only non-random correct responses were used in tabulating the results. Incorrect responses to such questions have been shown to be associated with random or unintended retrieval processes (Camp, Lachman, & Lachman, 1980; Camp, 1981). A 3 x 2 analysis of variance was conducted for all comparisons using the between-groups factor age level (younger, middle-aged, and older adults) and the within-S factor question type (fact retrieval and inference initiators). Post hoc comparisons were performed using Tukey's procedure, with an alpha level set at .05.

Process ratings. The mean ratings associated with age levels for fact retrieval and inference initiators are shown in Table 1.

Insert Table 1 about here

A statistically significant question type effect was found ($F=467$, $df=1,117$, $p<.01$, $w^2=.63$). Ratings associated with questions intended to induce fact retrieval had lower ratings on the three-point scale than inference initiators. This indicates that fact retrieval questions elicited more remembering whereas inference initiator questions elicited more 'figuring out'. Neither age nor age x question type effect reached significance. This measure was only taken for the multiple choice task.

Number of non-random correct responses. For the multiple choice task (results listed in Table 1), question type was significant ($F=151$, $df=1,117$, $p<.01$, $w^2=.26$) with more correct responses given for the fact retrieval questions than the inference questions. Although age was not significant, the age x question interaction was ($F=9.64$, $df=2,117$, $p<.01$, $w^2=.03$). Tests of simple main effects indicated that age level was not significantly related to the number of correctly answered fact retrieval initiators ($p>.15$). However, age was significantly related to the number of inference initiators answered ($F=4.87$, $df=2,117$, $p<.01$, $w^2=.06$). Post hoc comparisons revealed significant differences between young and older adults, and between middle-aged and older adults. These results are perhaps due to the longer focusing of attention required for these questions, as well as the use of alternative choices in conjunction with inferential reasoning. Such questions could have strained older adults' working memory capacities (or 'attentional resources' to use Craik's term).

In the true/false task, similar results were found with respect to a significant question effect ($F=82$, $df=1,117$, $p<.01$, $w^2=.18$) and a non-significant age effect, thus showing

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Insert Table 2 about here

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that fact retrieval initiators were answered more easily than inferential reasoning initiators at all ages. The age by question type interaction approached significance ($F=2.79$, $df=2,117$, $p<.06$, $w^2=.01$). Tests of simple main effects indicated that age level was a significant effect for fact retrieval questions ($F=4.52$, $df=2,117$, $p<.02$, $w^2=.06$). Post hoc comparisons revealed that younger and middle-aged adults were significanlty different in mean performance. No other comparisons reached significance. Age level was not significant for inference questions. These results may indicate that since the number of alternatives were less in the true/false task than in the multiple choice task, there was less strain on tne older persons' working memory capacity, thus enhancing their performance.

Confidence ratings. In the multiple choice task, question type was significant ($F=137$, $df=1,117$, $p<.01$, $w^2=.16$) with fact retrieval initiators being answered more confidently than inference initiators. No other effects were significant for this task. In the true/false task, question type was again significant ($F=106$, $df=2,117$, $p<.01$, $w^2=.14$) with fact retrieval items being answered more confidently than inference items. Age was also significant ($F=3.74$, $df=2,117$, $p<.03$, $w^2=.03$). Post hoc comparisons failed to reach significance at the .05 alpha level,

though increased age was associated with increased level of confidence. The age by question interaction was non-significant.

Response speed. To normalize the reaction times (RT's) associated with answering these questions, RT's were submitted to a reciprocal transformation, in order to obtain a measure of speed rather than RT (cf. Camp, 1981; Wainer, 1977).

In both tasks, there were a significant question type effects. Fact retrieval questions were answered much more rapidly than inference initiators ($F=312$, $df=1,117$, $p<.01$, $w^2=.32$ for the multiple choice task and $F=273$, $df=1,117$, $p<.01$, $w^2=.21$ for the true/false task). In both tasks, there was also a significant age effect, ($F=5.97$, $df=2,117$, $p<.01$, $w^2=.04$ for the multiple choice task and $F=12.34$, $df=2,117$, $p<.01$, $w^2=.11$ for the true/false task). Post hoc comparisons revealed that younger adults were significantly faster than older adults in both tasks. In the true/false task, younger adults were also significantly faster than the middle-aged group. In both tasks, the interaction effect was non-significant. These combined results indicate that the two question types elicit different mental processes, with inference questions requiring more time to be answered. In addition, this supports the notion of a general systemic slowdown associated with increasing age.

Reading speed. The average reciprocal reading times for questions in the true/false task were computed for each participant. The main effect for age was significant ($F=11.91$, $df=2,117$, $p<.01$, $w^2=.15$). Post hoc comparisons revealed that both middle aged and older adults required more time to read questions than younger adults. Mean reciprocal reading speeds for the three

groups were M=32, 26, and 23 for the young, middle-aged, and older groups, respectively.

Additional analyses. Coyne, Herman, & Botwinick (1980) measured response speeds for recognition memory in a lifespan development study. To adjust for the motor component present in recognition response speeds, they took a simple reaction time measure for each participant and subtracted it that participant's average recognition response latency. These adjusted latencies were used in subsequent analyses. Using this logic, average reading speed for each participant was subtracted from the average question answering speed for the fact retrieval questions in the true/false task (ie. Difference score = fact retrieval speed - reading speed). This was done since fact retrieval is a necessary but not sufficient condition for inferential reasoning to take place. (In addition, the lack of interactions between age and question type for our speed measures indicated that age level affected response speed for both types of questions in a similar way.) These difference scores again produced a significant age effect ($F=4.63$, $df=2,117$, $p<.02$, $w^2=.06$). Post hoc comparisons revealed that younger adults were significantly different from (i.e. faster than) both middle-aged and older adults for this measure. Therefore, age effects for speed of answering questions seem to be independent of reading speed and related psychomotor measures, a finding that replicates that found by Camp (1981). These results again support the idea that a general systemic slowdown in cognitive processing is associated with aging, although the types of processing used by

adults of different ages are qualitatively similar in these tasks (see Figure 1).

Insert Figure 1 about here

CONCLUSIONS

The results showed that the questions utilized did elicit different reasoning processes for all ages. This was indicated by both the ratings given by the subjects and the speed of response for fact retrieval and inference initiators.

The first hypothesis stated that the older adults would use more inferential processing since it would be more difficult for them to retrieve facts and would thus use inferentialreasoning by default. This hypothesis was not supported. The older adults answered as many or more items correctly than the young adults in all conditions except forthe multiple choiceinference questions.Theseresults provide further support for the contention thatolder adults canretrieve facts and make inferencesas well as younger adults as long as their working memory capacities are not overloaded.

The second hypothesis stated that the older adults would engagein more inferential reasoning than younger adultssince they would be less confident in their ability toremember. This hypothesisalso was not supported. The older adults were either as confident or more confident in their responsesthan younger adultsfor both experimental tasks and for both typesof questions.

The third and final hypothesis stated that older adults would utilize both fact retrieval and inferential reasoning more slowly than younger adults due to a general systemic slowdown associated with advancing age. This hypothesis was supported. Past research (Camp, 1981) as well as the present study found a significant age effect for both types of questions and in both tasks, with older adults responding more slowly. These results were independent of psychomotor speed.

Therefore, cognitive processes utilizing long term memory seem to be slowed by aging. However, older adults can accurately use both fact retrieval and inference reasoning processes for world knowledge systems as long as their working memory capacity is not strained.

Finally, in almost all instances the performance of our middle-aged adults was at an intermediate level between that of our older and younger participants. This suggests that age-related changes in higher level cognitive processes follow consistent patterns from young adulthood through old age.

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Table 1

RESPONSE MEANS -- MULTIPLE CHOICE TASK

AGE GROUP	PROCESS RATINGS		NONRANDOM CORRECT		CONFIDENCE RATINGS		RESPONSE SPEED	
	FR*	INF*	FR	INF	FR	INF	FR	INF
YOUNG	1.3	2.2	23.8	21.1	1.4	1.7	34.6	20.6
MIDDLE	1.3	2.1	24.8	20.7	1.4	1.7	32.1	17.8
OLDER	1.2	2.0	25.[illegible]	19.0	1.4	1.7	26.9	15.4

* FR = FACT RETRIEVAL INITIATORS; INF = INFERENCE INITIATORS;
Response speeds (1/RT): low scores = slow speeds

Table 2

RESPONSE MEANS -- TRUE/FALSE TASK

AGE GROUP	NONRANDOM CORRECT		CONFIDENCE RATINGS		RESPONSE SPEED	
	FR*	INF*	FR	INF	FR	INF
YOUNG	23.7	21.5	1.5	1.8	68.6	45.4
MIDDLE	26.0	21.7	1.4	1.6	52.8	33.1
OLDER	25.3	21.7	1.3	1.6	48.7	29.2

*FR = FACT RETRIEVAL INITIATORS; INF = INFERENCE INITIATORS;
Response speeds (1/RT): low scores = slow speeds

FOOTNOTES

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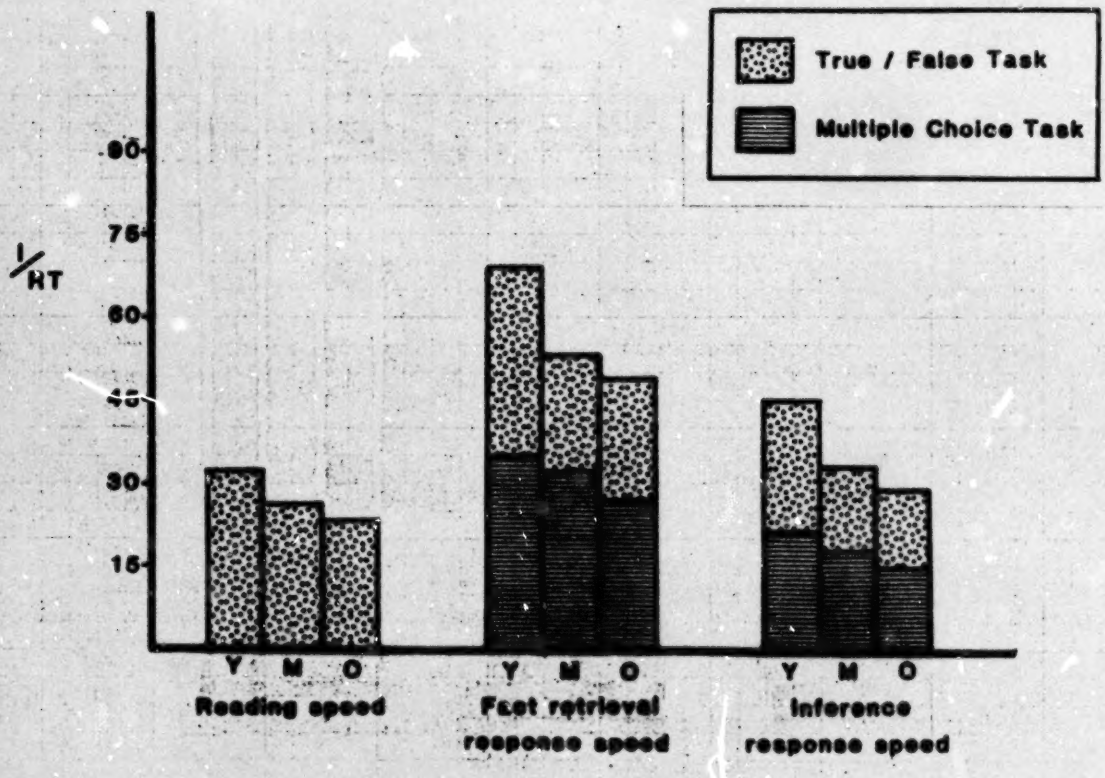

Figure 1. Response means for young (Y), middle-aged (M), and older (O) age groups (low scores = slow speeds).

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